Excessive nutrient application to agricultural land and intensive farming practices have led to an increase in sediment and phosphorus-bound Phosphorus (P) transported through runoff into waterways, threatening freshwater quality. The Rock River watershed is located on the across the US-Canadian border, whose flows originate from the Highgate and Franklin counties in Vermont and the Province of Quebec and discharges at Missisquoi Bay in the northeast arm of Lake Champlain, draining 9,090 hectares of land through a combined river length of 34 kilometers. This study focuses on the Vermont portion of the Rock River watershed, compromised between 0.15 and 0.93 of the watershed. Total Phosphorus (TP) at the bay exceeded its total maximum daily load standard of 25µg/L by 21µg/L in 2015 and is the most deteriorated lake segment. Phosphorus loading, being one of the significant limiting factors for aquatic life exacerbates algal blooms. Moreover, the regional climate trends of increasing temperature and precipitation, the combination of higher loading, higher temperatures, and increased erosion due to intensified storm events, further eutrophicates the bay. This in turn poses a threat to human health, diminishes recreational potential, and degrades the drinking water supply for over 200,000 residents.

In a regional analysis, the study area contributed the second highest sediment and phosphorous loading rate (1.33 ton/ha and 0.81 kg/ha respectively), plus the highest (7.522 tons) of total phosphorous outputs (Winchell, 2011). Other findings estimate that 85%-90% of total phosphorus load in the form of sediment originates from critical areas (CSAs) classified as cropland. I speculate that the Agriculture, Food and Markets has not enforced accepted agricultural practices (AAP) in small farms as rigorously or frequently as in larger farms, although the former accounts for 83% of Vermont’s total farms. Specifically, the small farms in Franklin County were only assigned a compliance inspector by the agency in 2013, therefore it is expected that the smaller farms may contribute more nutrient pollution than the larger farms due to their lack of oversight and knowledge regarding specific AAPs. The manufacturing and agricultural development of the study area has been steadily growing, and a 14.8% increase in the dollar value of agricultural products sold from 2007 to 2012, while the mean household income and average annual wage is lower than the rest of the state.

The Rock River Watershed? What are the economic values of these critical systems, land use practices, and competing tradeoffs both the mean household income and average annual wage is lower than the rest of the state. A Socio-Economic Lens on Identification of Critical Source Areas in the Rock River, Vermont

Introduction

Considering climatic, bio-physical and bio-chemical properties of surface and subsurface ecosystems, land use practices, and competing trade-offs between profit-seeking and sustainability, what are the areas that are more susceptible to sediment erosion and phosphorus leaching in the Rock River Watershed? What are the economic values of these critical source areas?

Methodology

I. Empirical estimation of annual soil loss (A) through the Universal Soil Loss Equation (USLE) A = R * K * LS * C * P

A: average annual soil loss (ton/ac/year)
R: rainfall erosivity factor
K: soil erodibility factor
LS: topographic factor
C: cover-management factor
P: support practice factor

II. Development of Critical Source Area Definitions

- Determine maximum P amount per unit area utilizing Vermont’s Water Quality Standards §3-01(A)(2)(c), “small drainage area into a lake”.
- Previous SWAT results were used to define P-CSAs: those >5 or 4 or 1.4 study area

III. Validation through a comparison to a previous study (Winchell, 2011)

- The estimated sediment of soil with another method: Soil and Water Assessment Tool (SWAT).
- Overly phosphorus and sediment load CSAs with property values.
- Utilized property price per acre ($/acre) data for the period between 1999 and 2003 estimated via artificial neural network (ANN) method.

The manufacturing and agricultural development of the study area has been steadily growing, and a 14.8% increase in the dollar value of agricultural products sold from 2007 to 2012, while the mean household income and average annual wage is lower than the rest of the state.

Discussion of Results

- My analysis delineates the Rock River Watershed into a spectrum of areas ranging from no sheet and rill erosion to a maximum sediment load of 709,514 tons and a mean annual value 28,614 tons.
- The maximum annual sediment loading rate of 77.5 tons/ha is spatially situated on the steepest regions, as is congruent with earlywarnings of USLE, while its mean value is almost three times as large as the previous study, indicating a possible overestimation of erosion.
- CSAs were defined as sediment rates greater than 11.2 ton/ha annually, the upper erosion limit for agricultural sustainability (Miller, 2007).
- Utilizing the threshold value for sustainable erosion, the sediment loading risk was significant in 368 ha, or 4.02% of the total study area.
- Considering the average surface discharge for three years (13,395,001,305 Lyr from 2012-2014) obtained from the USGS monitoring station 4042941.40 representing the runoff collected by the Rock River (extrapolated for the size of the watershed on the US territory), and state’s maximum allowable P export rate per hectare (0.012 mg/L) annually into tributaries, then the total study area’s phosphorus load should not exceed 42.26 kg/yr. When this allowable P export is compared to SWAT’s estimated TP load (7,522 kg/yr) and, then the severity of the river’s pollution level is revealed and corroborates why the State has classified 28.3 km of the river as impaired because of agricultural runoff and nutrient enrichment.
- Possible reasons for why USLE over predicts soil loss in comparison to the SWAT study:
  1. R factor was not calculated directly from the relationship between rainfall kinetic energy and its intensity.
  2. Deviation from the optimal result in slope lengths <122m. The slope did however, conform to the optimal slope angle (1-18%), with a mean slope percent of 1.65%.
  3. Loss of accuracy when I calculated each factor in the US unit system. More accurate factors results were obtained when converted all my data to SI units.

Validation through a comparison of sediment load to a previous study (Winchell, 2011). Utilized property price per acre ($/acre) data for the period between 1999 and 2003 estimated values by converting all my data to SI units.

Future studies should further validate the accuracy of the methods used for determining the critical source areas. Further insight into other possible causes of erosion vulnerability, and hence for contributing to pollution, are needed. Sediment and nutrient loads from properties of both lowest and highest property values have been calculated and interpolated to Lake Champlain’s water quality degradation. In the face of regulation changes, future analysis is needed to improve the USLE approach by utilizing field measurements. It would also be very valuable to explore whether small farms could have caused more erosion due to their less likely potential for investing in best management practices or due to the lack of regulatory enforcement. Future, further, studies for estimating the value of prime soil lost annually from cropland could be a powerful tool to incentivize better soil conservation practices.

Selected References


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